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ABSTRACT

A cognitive study examined expertise in managerial problem solving. Research questions asked what types of managerial knowledge do experts and novices use in representing and solving problems, and how do knowledge types develop over time? The 115 participants were divided into 9 levels of expertise: first through fourth year students in the management sciences program of Maastricht University and 2-, 5-, 12.5-, and 25-year working experts. Materials consisted of two case descriptions concerning real-life business situations. Students had a limited reading time after which the text was removed. Subjects carried out the following three assignments with the case information: recall of the case studied; a written analysis about the situation; and a management diagnosis about the situation. Results of the recall exercise suggested clear differences among novices, intermediates, and experts in the type of recall. An absolute maximum was reached at intermediate level. Experts recalled relatively more relevant information. Novices produced more declarative knowledge types than experts in the recall and case analysis exercise, while experts reproduced more inferences. (Contains 20 references.) (YLB)

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Introduction

Next to the established professions as medicine, law and engineering, the field of management sciences is considered as one of the new professions. For a long time management sciences were dominated by the view that managers are rational technicians or management engineers (Wagner, 1991). This resulted in the development of rational, behaviorist approaches to managerial problem solving with an emphasis on general principles of problem solving. Content knowledge was considered as less important. However, in the 1970s and the 1980s a growing skepticism rose about the power of general principles of problem solving (McCall & Kaplan, 1985). For example, Mintzberg (1973) found on the basis of observations and interviews that managers rarely employ rational approaches. As Mintzberg lacked modern tools from cognitive psychology for further examination of managerial problem solving, he considered his own study as "sketchy". More recent, so called 2nd generation expertise studies (Schragen, 1994) in the 1980s showed the importance of knowledge. In problem solving, experienced managers asked for less information and made more inferences from data, than students (E.g., Isenberg, 1986). The Isenberg study was one of the first that questioned the importance of general problem solving methods in the management sciences. The study was also one of the few in this field that applied methods for expertise research similar to those in medicine or physics. Basically, studies on managerial problem solving from a cognitive science perspective are still limited to a few (See e.g. VanHossen & Miller, 1994; Gijselaers & Woltjer, 1997), though a large area of studies on expertise development is available within the established professions. Nowadays, the general agreement about development of expertise is that the ability to solve problems in a certain knowledge domain is not only a result of better heuristics but also depends on one's knowledge

of a specific domain (e.g. Glaser & Chi, 1988; Ericsson & Smith, 1991; Schmidt & Boshuizen, 1993). Few studies, however, exist that examine this *knowledge* of novice and expert problem solvers in management sciences. Especially studies are lacking that include a large range and number of subject-groups. However, the growing importance of research on managerial decision-making and managerial expertise requires that studies are conducted that apply frameworks of expertise development as derived in mainstream cognitive psychology (Patel & Groen, 1991).

In many areas where expertise has been studied, consistent patterns have been found (Glaser & Chi, 1988) on the development of expertise over time. One of the most consistent findings in novice-expert comparisons in the area of medicine is the so-called intermediate effect (Schmidt, Boshuizen & Hobus, 1988). Intermediate students not only recall more propositions than novices but typically they also recall more than experts. The intermediate effect can be characterized as a time stage in the development of expertise. The development of expertise in general has a stagelike and discontinuous nature, according to findings of Schmidt and Boshuizen (1993) in the medical domain.

The goal of this cognitive study is to examine expertise in managerial problem solving. More specific, a (first) research question is: what kind or types of managerial knowledge (facts, concepts, principles, diagnoses) do experts and novices use in a) representing and b) solving problems in the management sciences? To answer this question seven types of knowledge were investigated in recall, analysis and solving of problems. A second research question was: how do the knowledge types develop over time? To answer this question, nine subject expertise groups were tested (from younger novices to older experts). Answers to these research questions will be an important input for current management education. If we know how a certain

expertise develops over time, education and training can better be adapted to this process of knowledge development.

Method

Subjects. The present study had 115 participants, divided into nine different levels of expertise: five student groups and four working expert groups (see table 1).

Table 1: Distribution of Subjects

Novice Students	Students 1th-year	Students 2nd-year	Students 3th year	Students 4th-year	Experts 2 year	Experts 5 year	Experts 12.5year	Experts 25 year
18	14	22	16	16	8	6	8	7

All the student groups were all selected out of the management sciences program of Maastricht University. Intermediates were called the third and the fourth year students (a few months before graduation). The 'emerging experts' (two groups with on the average two and five years of working experience) were graduates of the management sciences program. Finally the last two experts groups were selected on the criteria of about 12.5 and 25 year of working experience in the domain of management.

Materials. The materials consisted of two case descriptions, concerning real-life business situations. See appendix A for an English version of case A. To enhance the reliability and generalizability of the experiment, two cases were used. For each case two blank response sheets were included. Both cases were considered to be at intermediate level of difficulty, that is end of 3rd-year students should be able to solve them. Each case described managerial issues within an organization. Case A ('Flex

Ltd') concerned Organizational Development. The issue of Case B ('Crea Ltd') was about Human Resources Management. To improve external validity, the case content was verified by two business consultants. The content of the cases was selected within the existing management curriculum. The case content and canonical model explanation model ('solution') were developed with teachers of the curriculum concerned.

A limited reading time for the cases was set, based on the length of the case. In a pilot test it was found that subjects needed on the average 0.4 second per word to study a text. The fixed reading time of the cases was calculated as follows. Case A ('Flex Ltd') contained in the original Dutch text 339 words; 0.4 second a word leads to 2.15 minutes. (Case B: 425 words, 2.50 minutes reading time).

Procedure. Subjects were instructed to study a short case description in a fixed period of time, after which the text would be removed. The subjects were told to carry out three assignments with the case information shown. The subjects was told be in the position of business consultant. This was told to activate prior knowledge, in the knowledge domain to be investigated. Subjects were not allowed to consult the case description while working on the three assignments that the cases consisted of. The first assignment was a recall of the case studied. Subjects were asked to write down as much as possible they could remember of the case. As the subjects were not aware that they would be asked to recall the case, this is referred to as the '*incidental* recall method'. When the second case was offered, the subjects now were aware to expect a recall exercise, hence this second condition could be considered as an 'intentional recall method'. To neutralize the recall effect, the two cases (A, B) were offered in a mixed order. Next to the recall exercise, the subjects had to provide a written analysis about the situation presented in the management case. Finally, a

management diagnosis about the situation was required. All subjects received a small compensation for their participation.

Analysis. The original case texts were segmented into propositions (a small, meaningful unit of information containing a topic and a connected relation). In general, adjectives in sentences form the basis for separate propositions: I.e. the sentence 'Decision-making was getting more complex and tiresome' contains two propositions. The scores for every subject were based on a standard technique of proposition analysis (Patel & Groen, 1986). A recalled sentence could contain more than one proposition. For every complete proposition, the score '2' was given. However, sometimes the subjects recalled only a (substantial) part of a proposition, like: 'Decision-making was getting more complex'. In that case a score 1 was provided.

Both the case recall and case analysis protocols, as produced by the subjects, were scored against the original case text as following: 1. Case *recall* protocols were scored on a) Number of literal reproductions of the text (divided into relevant and irrelevant propositions by organizational experts) and b) Number of inferences. Inferences were defined as knowledge transformations, made on original text-propositions. Examples of inferences are conclusions and summaries. 2. Case *analysis* protocols were scored by counting the correct numbers of a) facts, b) inferences, c) managerial concepts, and d) diagnosis. A managerial concept was scored when subjects showed to use concepts like: "this is a *bureaucratic organization*".

Results

For comparing the case instruments, an analysis of variance was carried out for the combined results of case A and B. For comparing the two cases, the scores on the cases were standardized by using the percentage of propositions recalled. For example the scores of the subjects for the variable Total recall was divided by the maximum recall score for case A (107), leading to scores in percentages. The total recall in percentages of case A and B is depicted in figure 1:

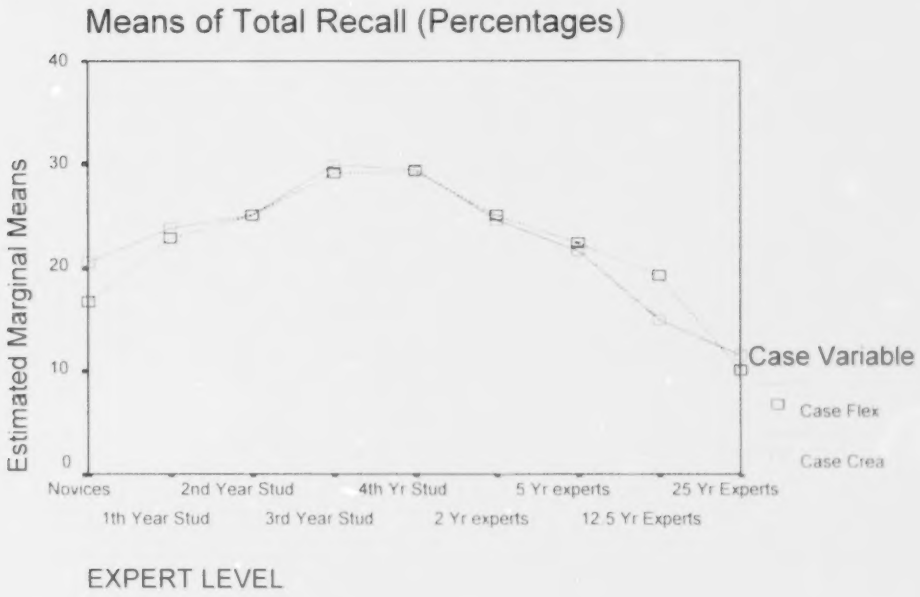

Figure 1: Total recall in percentages of case A and B compared

To compare the results of the two cases, a univariate analysis was carried out with the Factor Level of expertise and the independent variable Total recall score on case A and B (see table 2.). No case effect was found ($F(1,185) = 0.38$, $MS_e = 1.93$, $p = .846$), nor an interaction effect between cases A,B and level of expertise ($F(8,185) = 0.443$, $MS_e = 22.65$, $p = .849$). As expected, a significant effect for Level of Expertise

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($F(8,185) = 13.54$, $MS_e = 692.16$, $p = .000$) was found for the total recall score of case A and B. These results suggest that the differences in relative scores of the subjects on the two cases are not different. Hence, for further analysis, the scores on case A and B were combined into one case score.

Table 2: The results on the two measurement instruments (cases) compared for the varable total recall on the two cases.

Tests of Between-Subjects Effects — Dependent Variable: % Total Recall

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5851,080	17	344,181	6,734	,000
Intercept	84569,749	1	84569,749	1654,652	,000
CASE Variable	1,932	1	1,932	,038	,846
EXPERTLEVEL	5537,290	8	692,161	13,543	,000
CASE Variable * EXPERTLEVEL	181,205	8	22,651	,443	,894
Error	9455,402	185	51,110		
Total	125073,518	203			
Corrected Total	15306,483	202			

a R Squared = ,382 (Adjusted R Squared = ,325)

Analysis of the literally recall. For the analyses of the cases, three types of recall were distinguished: a) Recall that was relevant related to the problems in the case, b) Recall that was not relevant, and c) the Total recall (a+b). Significant effects of level of expertise were found for:

Total recall: $F(8,103) = 10,40$; $MS_e = 440,15$, $p = .000$;

Relevant recall: $F(8, 103) = 10,42$; $MS_e = 228,40$, $p = ,000$;

Irrelevant recall: $F(8, 103) = 5,53$; $MS_e = 49,64$, $p = ,000$.

The relation between the three average types of recall and the nine levels of expertise is depicted in figure 2, showing that after an initial increase, the amount of recall actually decreases, beyond the level of intermediate subjects. In other words: the shapes of the curves seem to have an 'inversed U-relation'.

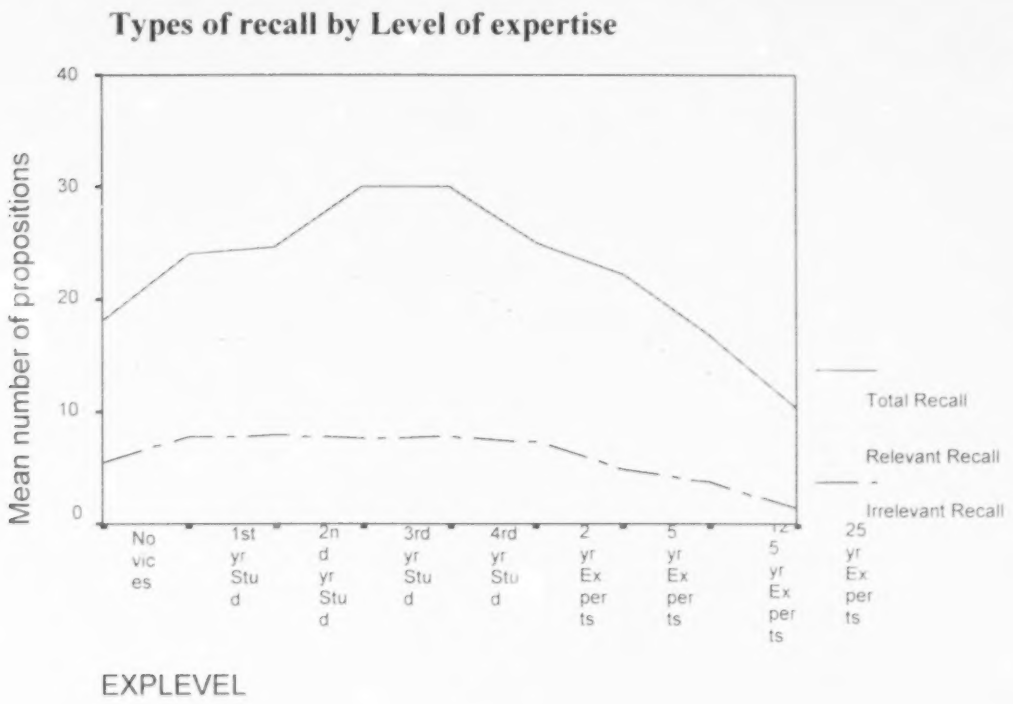

Figure 2: Means of produced types of literally recall as a function of expertise (combined results case A + B).

The number of inferences. Results show that the number of inferences continuously increases with level of expertise, see figure 3. For the number of inferences a significant effect of level of expertise was found ($F(8,103) = 27,55$, $MS_e = 113,15$; $p = .000$).

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Figure 3: Inferences by level of expertise (recall exercise).

Analysis of the problem solving assignment.

Facts. The number of facts used in problem solving shows an 'inverted U-relation'. A significant effect was found ($F(8,105) = 3,089$; $MS_e = 12,22$, $p = .004$).

Inferences. For the number of inferences a significant effect of level of expertise was found ($F(8,105) = 28,31$, $MS_e = 69,92$, $p = .000$). As in the recall assignment the number of inferences increases continuously with level of expertise.

Economical concepts. A statistically significant effect of level of expertise was found for the use of the number of managerial concepts ($F(8,105) = 16,07$; $MS_e = 13,86$, $p = .000$).

Diagnostic accuracy. For the number of correct diagnoses a significant effect of level of expertise was found ($F(8,105) = 16,02$, $MS_e = 10,05$, $p = .000$).

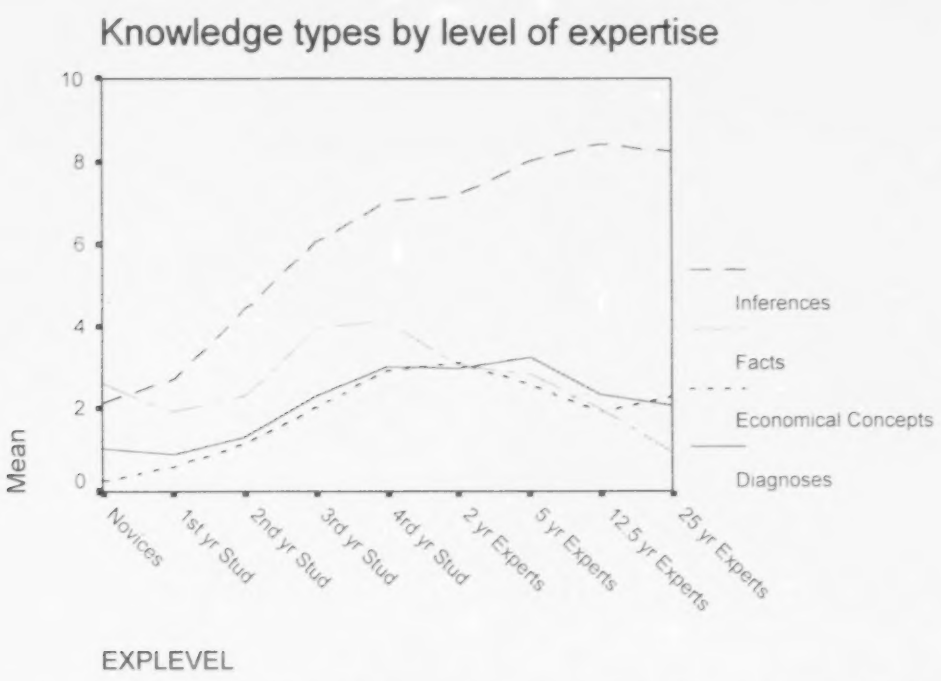

Figure 4: Means of counted facts, inferences, concepts and diagnoses as a function of expertise level.

In figure 4 the relation between four different types of knowledge used during managerial problem solving is depicted for the nine levels of expertise. Typically the relation between level of expertise and a) facts, b) concepts and c) diagnoses shows three times an inverted U-form. This implies that after an initial increase, the number of facts, concepts and diagnoses actually decreases, beyond the level of intermediate subjects.

Discussion and implications

The results out of the recall excercise suggest clear differences between novices, intermediates and experts in the type of recall. Concerning the amount of totall recall, an absolute maximum was reached at intermediate level. The shapes of all the recall-curves seem to show an 'inversed U-relation'. In contrast to novices and students,

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experts recall relatively more relevant information but very few irrelevant information. In the medical domain, Coughlin & Patel (1986) emphasized the higher selective perception ability of experts, in contrast to novices who identically represent relevant and irrelevant information. Apparently, good problem solvers (experts) make a better (more relevant) representation of the problem, as often is found in expertise research (Coughlin & Patel, 1986).

Another general conclusion is that novices produce more declarative knowledge types literal (propositions and facts) than experts, both in the recall and the case analysis exercise, while the experts groups reproduced more inferences (summaries, conclusions). In other words, the findings suggest a shift in use of declarative knowledge types by novices toward a more abstract (higher-order) level of expertise by experts. This shift, together with the decrease of applied knowledge at the highest expert levels can probably be explained by a) compilated or b) encapsulated knowledge bases of experts (Schmidt & Boshuizen, 1993).

1. Knowledge encapsulation. Schmidt & Boshuizen (1993) define knowledge encapsulation of experts' knowledge as the subsumption of lower-level, detailed concepts under a smaller number of high-level concepts with the same explanatory power. This explanation refers to the idea that experts reason with more condensed or packed types of knowledge. Encapsulation is a cognitive process operating on declarative knowledge, as it concerns the hierarchical structure of *concepts* in the human mind (Schmidt & Boshuizen, 1993).

2. The decrease of applied knowledge at the highest expert levels can also be explained a result of *compiled* knowledge bases of experts (Schmidt & Boshuizen, 1993). Knowledge compilation, in contrast to encapsulation, operates upon procedural knowledge. This process is described by Anderson (1987) and explains

the phenomenon of packed reasoning. Experts may skip several (automated) phases in explaining problems and arguing solutions in case protocols, which can explain why experts use less knowledge in case protocols.

3. Another possible explanation for the decrease of applied knowledge at the experts levels may be that experts *need* less knowledge to solve problems. It is known that experts work more efficient (more quickly and directly) than novices because of the nature of their well-organized knowledge base (Ericson & Smith, 1991). Intermediate students for example often carry out many irrelevant searches in seeking for a right solution to solve problems (e.g. Gijselaers & Woltjer, 1997). It is also generally known that experts have more experience in recognizing or 'typical patterns or case situations'. These two facts may lead to the idea that experts are better able to use the right and necessary knowledge in the right situations, implying that experts use knowledge more *effective*. Probably, this can also explain why experts recall very few irrelevant case information.

A final point to be discussed here is the fact that results suggest gradually and continuous shaped curves, in contrast to several other novice-expert studies that used three or just two (Van de Wiel, 1997) subject-groups, leading to discontinuous graphical shapes of expertise development. The question here is how the shape of these graphical curves would change by using a very large number of subject-groups. The present study used nine subject-groups. Also in this study the highest experts levels had consisted of very experienced managerial experts (on the average more than 25 years of working experience), which is much more than usually in expertise studies. The results of this study can therefore be considered as a refinement of earlier expertise studies.

Recommendations for further research. In this research a cross-sectional design was used: all nine subject-groups were tested in the same year, due to time limitations. A suggestion for further research is to follow the developments of one group, hence using a longitudinal design. Further, in this research absolute differences are explored between subject-groups that were selected on the criteria of difference in study progress or work experience. It would be interesting however to further explore the relative expertise, that is exploring differences in performances between individuals in one group (See also VanFossen & Miller, 1994) on behave of demographical variables such as age and gender or student characteristics (see also Gijselaers & Arts, 2000).

Implications for education. This study demonstrates for educational practice the importance of a focus on the acquisition of *content knowledge* (besides the acquisition of heuristics) in order to become expert in a specific domain. Students should however not only be provided with a great amount of domain specific content knowledge. The results above show that (especially) intermediate students possess of a great *amount* of declarative knowledge but, compared to experts, seem to be less able to apply this knowledge, as they make relatively less operations (inferences) with this knowledge. This finding is in agreement with the often heard criticism that managerial education delivers graduated students that posses a lot of knowledge but are not yet able to use the appropriate knowledge in a business context. Also Van de Wiel (1997) concluded that expert knowledge, in contrast of student knowledge, seems to be *organized* in such a way that it is readily applicable in practical settings. To overcome this transfer problem a focus not only should be on acquiring knowledge, but students should also be trained in using knowledge effectively, such as learning to separate relevant from irrelevant knowledge in a given context.

Another aspect here is what Leinhardt, McCarthy Young, & Merriman (1995) state in the context of *transfer*: Applying knowledge in education involves labeling, differentiating and justifying it. These are typically cognitive activities where education is focused on while practical contexts require executing, applying and prioritizing knowledge. This may be an explanation why intermediate students produced fewer inferences than experts. Hence, the use and integration of declarative knowledge into practical situations should be fostered. This can be realized by applying knowledge in *real-life* situations through *realistic* cases (Christensen, 1987). The adoption of the case method in education is one response by business schools to the discrepancy between problem solving as it occurs in the context of real organizations and as it is described in textbooks. The case method here emphasizes understanding the situational context of a business problem (Christensen, 1987), which can lead to a better transfer of knowledge.

Conclusions

The present study revealed differences in the representation and usage of content knowledge between experts and novices, concerning:

1. The number of knowledge types produced. The results show that experts in management sciences in general produced *less* knowledge types than novices. Experts especially produced less: irrelevant recall, literal propositions, concepts and diagnoses. The results visually seem to show an "inverted U-relation": after an initial increase, the amount of this knowledge decreases, beyond the level of intermediate subjects. However, both in the recall and the problem solving assignment the number of *inferences* continuously increased with level of expertise, showing visually a linear relation, as the number of inferences produced was higher for every level of expertise.

Concerning the amount of knowledge produced an *intermediate* effect of the 3rd- and 4th-year students appeared for both cases and all knowledge types, except inferences.

2. Qualitative aspects of the knowledge produced by the subjects in the case assignments. The findings suggest a shift in use of declarative knowledge types (literal propositions and facts) by novices through an extensive use of all types of knowledge by intermediates toward a more abstract (higher-order) level of expertise (by using more inferences) by the experts.

3. Further, the results in general imply that the findings of Schmidt and Boshuizen (1993) in the medical domain and the model of expertise development as formulated by Chi, Glaser and Rees (1982) can be applied to the management sciences. A refinement that can be made here is that the present study suggests expertise development curves that are gradually and continuously shaped. This leads to the conclusion that the development of expertise is a gradual and continuous process (Van de Wiel, 1997).

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Appendix A:

The first case used in the experiment, Case A: Flex, Ltd.

Mr. Fox is director and founder of an employment agency (Flex, Ltd.). More than 25 local offices are divided in several regions. Most offices are located in the South of the Netherlands. The state of Zeeland covers more offices than the state of Limburg. Flex showed a remarkable growth: from 70 to 150 employees, sales growing from NLG 15 million to NLG 50 million. Average sales of competitors are about $ 60 million.

Mr. Fox's desk contains a growing number of files. Decision-making is getting more complex and tiresome. A growing number of files remain closed. Mr. Fox prefers an informal organization, employees can just drop in his office. Local directors contact Mr. Fox frequently for detailed issues, meanwhile complaining about a lack of central policy making and clear company vision.

Due to the development of new kinds of jobs, Flex decided to specialize. Different offices specialize in different job areas. Some offices are specialized in administration, industry, general management and health care. This is unlike in the past when offices covered all job areas. It was not unusual that even physicians and architects acquired new jobs through the offices of Flex company.

Local offices are not used to this change. Directors of these offices complain about their job because it is no longer challenging now that they are only targeting at a single profession or job area. It shows that local offices are often getting in conflict with other local offices when negotiating with the same company or client. In addition some local offices initiated their own market research. Clients (companies looking for new personnel) complain that they have to contact different offices for different job specialties.

Mr. Fox considers possibilities to improve the performance of Flex. He thinks about splitting shares. The accounting department, however, is convinced that Mr. Fox should lower his expenses for public-relations and sponsoring (Mr. Fox considers becoming a sponsor for a tennis-club). The accounting department argues that more money should be allocated to hiring new people for the local offices, or development of a new house-style for the entire organization. The IT-department is convinced that the development of a new financial accounting system provides better and faster information about the company's cash-flow. In addition the write-off period for computers should be reduced to four years.